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ABSTRACT

The Mathematics Attitude Scale (Aiken, 1974) purports to reflect attitude toward mathematics on two basic dimensions, enjoyment and value. While this scale is widely used in mathematics research, the only empirical evidence supporting the two-factor structure is the item analysis of college freshmen responses. The present study examines the suggested factor structure for 96 elementary teachers. The responses of the teachers were subjected to both item analysis procedures and selected factor analysis algorithms. Because of the exploratory nature of this research, principal component and classical factor analyses (using squared multiple correlation coefficients as initial estimates of communality) were employed in conjunction with several rotation procedures. The resulting three-factor solution (enjoyment, general value, and personal value) is more meaningful both psychologically and empirically than the original two-dimension scale, given a sample of in-service teachers. While internal consistency estimates for the first two factors were only slightly improved by imposing the new structure, a meaningful third factor with an internal consistency of .78 emanated. Moreover, increases in item discrimination indices were found. (Author/RC)

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EXPLORATIONS IN MATHEMATICS ATTITUDE:
AN EMPIRICAL INVESTIGATION OF THE AIKEN SCALE

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Purpose

The Mathematics Attitude Scale (Aiken, 1974) purports to reflect attitude toward mathematics on two basic dimensions, enjoyment and value. While this scale has begun to be widely adopted in mathematics research, the only empirical evidence presented in support of the two-factor structure of the scale has been the item analysis of the responses of 185 college freshmen obtained by Aiken in the fall of 1972. The present study was undertaken as part of a larger study of attitudes toward mathematics to validate Aiken's suggested factor structure for a sample which differs from that used in the development of the scale.

Sample

The data were collected from 96 elementary school teachers in four northern New England school districts. Each of the cooperating teachers had been randomly selected from a group which had volunteered to participate in a National Science Foundation sponsored study of alternative approaches to in-service mathematics training. The 96 teachers involved in the study reported here include members of both the experimental and control group of this larger study. All analyses were carried out on pretest data from the larger study in order to avoid the influence of any treatment effects.

Instrumentation

The Mathematics Attitude Scale (Aiken, 1974) is a Likert-type scale which purportedly is comprised of two subscales. The first subscale, which consists of 11 items, is designed to detect variations along an Enjoyment of Mathematics dimension. The second is comprised of 10 items and is designed to detect variations along a Value of Mathematics dimension. Evidence reported by Aiken for the two-subscale structure consists of alpha coefficients of .95 and .85 for the two respective scales and item-total correlation indices of .75 and above for the Enjoyment Scale and .60 and above for the Value Scale. These data were obtained from the administration of the 23 original Enjoyment and Value items randomly arranged with 17 other items concerned with interests, achievement and other biographical information. The data were obtained from 185 college freshmen in the fall of 1972.

Analysis of Data

Pretest responses of the sample (N=96) to the Mathematics Attitude Scale were subjected to both item analysis procedures and selected factor analysis algorithms. Because of the exploratory nature of this research, Principal Component and Classical Factor Analyses (using squared multiple correlation coefficients as initial estimates of communality) were employed in conjunction with several rotation procedures. Items were omitted from the scale according to several criteria. First, item groupings should contribute to a psychologically meaningful simple structure. Second, item-total correlations for each subscale should exceed the generally acceptable

level of .40 (Ebel, 1967). And third, the internal consistency of the resulting factors should be at a level which indicates acceptable accuracy of measurement (i.e., within the range of the coefficient suggested by Aiken).

Results

Results of the initial item analysis using Aiken's original subscale structure are presented in Tables 1 and 2. Correlations of items with their respective subscale totals fell below those of the original sample (i.e., .75 as a minimum for the Enjoyment Scale and .60 as a minimum for the Value Scale). The item-total correlations show 3 of the 11 Enjoyment Scale items with correlations below .75 and 7 of the 10 Value Scale items with correlations below .60, indicating a variation in performance for this sample when compared with the original sample of college freshmen. However, internal consistency estimates (coefficient alpha) for the two subscales were .92 and .81 for the Enjoyment and Value Scales, respectively, essentially the same as those reported by Aiken.

Principal Component Analysis results reflected in Table 3 show a five-component solution with items 3 and 15 forming the fifth dimension while item 13 contributes heavily to the fourth. Factor Analysis techniques using squared multiple correlations as estimates of communality (Table 4) also reflect a five-factor structure with items 3, 13 and 15 functioning essentially the same as in the Principal Component solution. Both of the factor matrices presented use VARIMAX rotations.

Items 3, 13 and 15 were all components of Aiken's original Value Scale. Relatively low indices of .35, .27 and .41 were evident upon examination of

the item-total correlations from our original item analysis (see Table 1). These poor discrimination indices were viewed as evidence that these items did not contribute to the construct of Value of Mathematics, at least for the sample being studied. In addition, when these same items were examined relative to their contribution to the newly formulated factors, discrimination indices for them were .25, .36 and .44, respectively. Finally, the alpha coefficients of the five-factor solution were examined, and, on the basis of estimates of .68 and .46 for the last two factors, items 3, 13 and 15 were omitted from further analyses.

The remaining 18 items were analyzed using Classical Factor Analysis techniques. The resulting factor matrix (Table 5) was generated using squared multiple correlations as initial estimates of communality and a VARIMAX rotation.

The original 11-item Enjoyment Scale remained intact with the exception of items 5, 6 and 12. Item 5, "I am interested and willing to use mathematics outside school and on the job," loaded¹ on the Enjoyment factor but also loaded on the third factor. Item 6, "I am interested and willing to acquire further knowledge of mathematics," clearly loaded on the third factor. Item 12, "I would like to develop my mathematical skills and study this subject more," loaded on both the second and third factors.

The second and third factors appeared to represent a splitting of the original Value dimension into factors of General Value and Personal Value. The loading on these two factors of those items, which were originally considered to belong to the Enjoyment Scale, appeared conceptually

¹ $\pm .30$ was considered the criterion for a significant factor loading (Child, 1970).

consonant with these factor labels.

This three-factor solution was resubmitted to item analysis procedure. Item-total correlations for the newly formulated 9-item Enjoyment Scale (Table 6) were generally improved over the original structure, the minimum discrimination index now being a respectable .53. The internal consistency estimate (coefficient alpha) for this factor was .93.

The second factor, which has been labelled General Value of Mathematics (Table 7), also manifested improved discrimination indices when compared with the original Value dimension, the minimum item-total correlation now being .44. The new 8-item factor also demonstrated a respectable internal consistency estimate of .83.

The third factor, Personal Value of Mathematics (Table 8), also exhibited acceptable discrimination indices. The minimum item-total correlation of .44 for this factor is an indication of the contribution of these items to this dimension of Value. The coefficient alpha for this factor was .78.

Conclusions

The three-factor solution arrived at through Factor Analytic techniques results in a scale which appears more meaningful both psychologically and empirically than the original two-dimension scale, given a sample of in-service teachers. While internal consistency estimates for the first two factors were only slightly improved by imposing the new structure, a meaningful third factor with respectable internal consistency (.78) also was demonstrated. Along with the general improvement of the item discrimination indices, these results suggest that the two-subscale scoring procedure

advocated by the developer is questionable, particularly when dealing with subjects who are not college freshmen.

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TABLE 1*

Mathematics Attitude Scale: Enjoyment of Mathematics

	<u>Item Correlation with Subscale Total</u>
2. I have always enjoyed studying mathematics in school.	.80
4. Mathematics is enjoyable and stimulating to me.	.81
5. I am interested and willing to use mathematics outside school and on the job.	.56
6. I am interested and willing to acquire further knowledge of mathematics.	.43
7. Mathematics is very interesting, and I have usually enjoyed courses in this subject.	.83
11. I enjoy going beyond the assigned work and trying to solve new problems in mathematics.	.76
12. I would like to develop my mathematical skills and study this subject more.	.30
17. Mathematics is dull and boring because it leaves no room for personal opinion.	.53
18. I have never liked mathematics, and it is my most dreaded subject.	.87
19. Mathematics makes me feel uneasy and confused.	.80
21. Mathematics makes me feel uncomfortable and nervous.	.79

* Items with negative directionality were analyzed with a reverse scoring procedure; therefore all ITC values are positive.

TABLE 2

Mathematics Attitude Scale: Value of Mathematics

	<u>Item Correlation with Subscale Total</u>
1. Mathematics is needed in order to keep the world running.	.42
3. Mathematics has contributed greatly to science and other fields of knowledge.	.35
8. Mathematics is not important in everyday life.	.53
9. Mathematics is not important for the advance of civilization and society.	.62
10. Mathematics helps develop a person's mind and teaches him to think.	.63
13. An understanding of mathematics is needed by artists and writers as well as scientists.	.27
14. Mathematics is less important to people than art or literature.	.52
15. There is nothing creative about mathematics; it's just memorizing formulas and things.	.41
16. Mathematics is needed in designing practically everything.	.54
20. Mathematics is a very worthwhile and necessary subject.	.68

TABLE 3
Mathematics Attitude Scale
21-Item Scale
Principal Component Analysis
VARIMAX Rotation

<u>Item</u>	<u>Factor 1</u>	<u>Factor 2</u>	<u>Factor 3</u>	<u>Factor 4</u>	<u>Factor 5</u>
1	0.28332	0.61570	-0.03625	-0.16476	-0.23289
2	0.85068	0.20883	0.09648	-0.04478	0.00758
3	-0.02073	0.29751	0.04039	-0.12761	-0.77610
4	0.84023	0.26446	0.11732	-0.02518	0.00691
5	0.42175	0.04424	0.61319	0.36136	-0.01222
6	0.24520	0.07049	0.79917	0.04849	-0.08238
7	0.82660	0.29731	0.16918	0.01157	0.09828
8	-0.23659	-0.58380	-0.40619	-0.01575	0.04964
9	-0.16269	-0.74413	-0.10906	-0.17635	0.04400
10	0.10383	0.57963	0.35179	0.27923	-0.15176
11	0.74846	0.19830	0.26048	0.08220	0.06007
12	0.09659	0.30910	0.69208	-0.13218	-0.12520
13	0.02776	0.15377	-0.08579	0.82118	0.03645
14	0.02964	-0.50800	-0.33641	-0.35239	0.08006
15	-0.19051	-0.08258	-0.18046	-0.23885	0.77195
16	0.09781	0.45695	0.21349	0.50642	-0.08081
17	-0.49859	-0.05915	-0.13277	-0.49909	0.21572
18	-0.88490	-0.08325	-0.19258	-0.08083	0.07093
19	-0.86260	-0.07742	-0.02336	-0.13889	0.22615
20	0.25882	0.76465	-0.01771	0.14337	-0.11774
21	-0.82538	-0.05258	-0.09010	-0.14521	0.21960

TABLE 4
Mathematics Attitude Scale
21-Item Scale
Classical Factor Analysis
VARIMAX Rotation

<u>Item</u>	<u>Factor 1</u>	<u>Factor 2</u>	<u>Factor 3</u>	<u>Factor 4</u>	<u>Factor 5</u>
1	0.26003	0.50315	0.03172	-0.07176	-0.19554
2	0.82416	0.22903	0.11758	-0.04543	0.01985
3	-0.01363	0.29730	0.05990	-0.08481	-0.55721
4	0.81669	0.28118	0.13744	-0.02385	0.01693
5	0.40022	0.08905	0.57225	0.32892	-0.02258
6	0.23582	0.11716	0.70672	0.04457	-0.10332
7	0.81374	0.32812	0.17999	0.00731	0.12955
8	-0.23326	-0.52899	-0.35273	-0.05495	0.09954
9	-0.16361	-0.65759	-0.11791	-0.18823	0.09643
10	0.11219	0.55168	0.31664	0.25823	-0.14475
11	0.70726	0.21548	0.25798	0.09080	0.03295
12	0.11372	0.32694	0.51816	-0.06789	-0.12595
13	0.03434	0.15244	-0.02274	0.63815	0.02157
14	-0.00278	-0.45025	-0.28493	-0.36253	0.10959
15	-0.17787	-0.16658	-0.17298	-0.18657	0.55032
16	0.10954	0.40757	0.21303	0.42125	-0.11509
17	-0.45376	-0.12067	-0.16577	-0.39007	0.14929
18	-0.86861	-0.09176	-0.21249	-0.08477	0.08597
19	-0.85494	-0.05476	-0.02260	-0.16621	0.30700
20	0.24721	0.70992	-0.00034	0.16741	-0.13804
21	-0.80069	-0.03990	-0.09856	-0.16502	0.28931

TABLE 5

Mathematics Attitude Scale
Revised 18-Item Scale
Classical Factor Analysis

<u>Item</u>	<u>Factor 1</u>	<u>Factor 2</u>	<u>Factor 3</u>
1	0.27423	0.48978	-0.00936
2	0.82605	0.18173	0.10403
4	0.81629	0.24109	0.12396
5	0.38609	0.16774	0.64189
6	0.22567	0.16727	0.67249
7	0.79681	0.28467	0.15536
8	-0.23746	-0.52788	-0.31631
9	-0.17335	-0.68848	-0.11022
10	0.11838	0.61634	0.32036
11	0.70123	0.22120	0.25609
12	0.11739	0.33908	0.42505
14	0.00148	-0.53961	-0.31562
16	0.11838	0.48471	0.29353
17	-0.45342	-0.21340	-0.24991
18	-0.86957	-0.11968	-0.23495
19	-0.84866	-0.13642	-0.10827
20	0.26221	0.75280	-0.03086
21	-0.79912	-0.11966	-0.17409

TABLE 6

Mathematics Attitude Scale: Enjoyment of Mathematics (Factor 1)

	<u>Item Correlation with Subscale Total</u>
2. I have always enjoyed studying mathematics in school.	.81
4. Mathematics is enjoyable and stimulating to me.	.83
5. I am interested and willing to use mathematics outside school and on the job.	.53
9. Mathematics is very interesting, and I have usually enjoyed courses in this subject.	.83
11. I enjoy going beyond the assigned work and trying to solve new problems in mathematics.	.75
17. Mathematics is dull and boring because it leaves no room for personal opinion.	.53
18. I have never liked mathematics, and it is my most dreaded subject.	.88
19. Mathematics makes me feel uneasy and confused.	.82
21. Mathematics makes me feel uncomfortable and nervous.	.75

TABLE 7

Mathematics Attitude Scale: General Value of Mathematics
(Factor 2)

	<u>Item Correlation with Subscale Total</u>
1. Mathematics is needed in order to keep the world running.	.44
8. Mathematics is not important in everyday life.	.59
9. Mathematics is not important for the advance of civilization and society.	.63
10. Mathematics helps develop a person's mind and teaches him to think.	.64
12. I would like to develop my mathematical skills and study this subject more.	.44
14. Mathematics is less important to people than art or literature.	.54
16. Mathematics is needed in designing practically everything.	.51
20. Mathematics is a very worthwhile and necessary subject.	.66

TABLE 8

Mathematics Attitude Scale: Personal Value of Mathematics
(Factor 3)

	Item Correlation with Subscale Total
5. I am interested and willing to use mathematics outside school and on the job.	.54
6. I am interested and willing to acquire further knowledge of mathematics.	.58
8. Mathematics is not important in everyday life.	.54
10. Mathematics helps develop a person's mind and teaches him to think.	.54
12. I would like to develop my mathematical skills and study this subject more.	.52
14. Mathematics is less important to people than art or literature.	.46
